CONTRIBUTIONS TO THE PETROGRAPHY OF JAVA AND CELEBES

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In a short visit to Java and Celebes in 1910 one of the authors visited several localities in Java, the rocks of which have been described by Verbeek,[1] and also the region of the Pic de Maros in Celebes, from which rocks were collected by Paul F. Sarasin and subsequently were described by C. Schmidt.[2] Part of the material collected on this visit has been analyzed chemically by the other author of this paper, and the analyses have been published, for the most part, without special description in the second volume of *Igneous Rocks* recently printed.[3] It is the purpose of this paper to call attention more specifically to the characters of the rocks analyzed, and to point out certain chemical and mineral relationships between the leucitic lavas of Mt. Mouriah in Java and the shonkinites and nephelite syenites in the vicinity of the Pic de Maros in Celebes.

Mt. Mouriah in the Diapara Residency, northeast of Semarang, on the north coast of Java has been described by Verbeek as an extinct volcano, 1595 m. high, which has undergone extensive erosion but still exhibits evidences of two large circular craters. Associated with it are two smaller volcanoes of similar character, Paliaïan and Tülering. The rocks of these mountains are exclusively leucitic, but some varieties are poor in leucite. Other leucitic lavas occur in the small volcano Lourous, and the larger, much eroded volcano Ringgit, in Besouki Residency in Eastern Java. Leucitic rock, together with phonolites, also occurs on the island

[1] R. D. M. Verbeek and R. Fennema, *Java et Madoura*, Amsterdam, 1896.

[2] P. and F. Sarasin, *Insel Celebes; Anhang, Untersuchung einiger Gesteinssuiten.* Wiesbaden: C. Schmidt, 1901.

[3] J. P. Iddings, *Igneous Rocks*, II. New York, 1913.

Bawéan, between Java and Borneo. Verbeek states that Mt. Mouriah is in large part tuffs and breccia with some flows of massive lava. He describes the rocks as chiefly leucite tephrites and leucitites with small amounts of feldspar in the groundmass; there being all gradations between these varieties. Olivine-bearing varieties are much fewer. In some of the rocks there are phenocrysts of leucite 5–10 mm. in diameter, and in exceptional instances 15 mm. The groundmass of these rocks is in most instances dark gray to black, dense and aphanitic, less often porous.

Two of the localities on Mt. Mouriah mentioned in Verbeek's description were visited in 1910: one was the stream Kali Gillinan, near the village Masin, on the south slope of the mountain above Bareng; the other locality was the stream Kali Sekatak, below the village Ragou, above Petjangaän, at the west base of the mountain. The first stream has a narrow channel at the place visited, and washes great bowlders of lava, and has short beaches of smaller bowlders and gravel. The second stream is much larger, flows in more open country below Ragou, and has long reaches of gravel and bowlders. In both places the bowlders represented great varieties of leucitic rocks which were mostly dense and compact and extremely fresh and unaltered by weathering, leucite crystals at the surface of the bowlders being transparent, or only slightly whitened in some instances, but completely altered in others. However, when the rocks are broken the interior portions usually appear to be very fresh, which proves to be the case when their sections are studied microscopically. These leucitic rocks, although considered by Verbeek to be possibly of late Tertiary age, are as fresh and as well preserved as modern lavas, or as many Tertiary lavas in the arid regions of Western America. In places where they have been covered by soil and vegetation for long periods of time they are completely decomposed for a short distance from the rock surface, as Mohr has shown to be the case with andesitic rocks in other parts of Java. Of 37 specimens collected from various bowlders at the two localities named, 8 varieties have been analyzed chemically, the analyses and norms being given in Table I, together with analyses of lavas from two active craters in other parts of Java; a short petrographic description of each follows.

TABLE I

Analyses of Lavas from Java

	1	2	3	4	5	6	7	8	9	10
SiO_2	51.85	50.18	48.32	48.66	47.73	46.54	46.60	45.03	55.42	51.12
Al_2O_3.....	19.08	17.82	17.81	17.69	17.93	15.95	16.73	16.59	17.39	19.59
Fe_2O_3.....	4.25	4.04	4.65	4.66	4.47	5.24	4.17	4.55	1.56	2.86
FeO......	2.69	3.89	4.62	4.40	4.58	5.51	4.78	6.37	6.82	6.53
MgO.....	1.48	2.88	3.37	3.03	4.27	4.70	4.65	3.95	3.28	4.47
CaO......	5.81	7.19	9.15	6.43	9.59	10.09	10.82	11.09	7.57	9.54
Na_2O.....	4.46	3.29	3.14	3.93	3.62	2.28	2.62	3.53	2.41	3.11
K_2O......	6.61	6.65	4.79	6.10	4.81	4.44	5.47	5.29	2.67	0.57
H_2O+....	0.55	0.96	0.82	0.80	0.44	0.52	0.71	0.34	0.17	0.11
H_2O-....	0.49	0.55	0.17	0.58	0.24	0.59	0.45	0.15	0.00	0.00
TiO_2......	0.66	0.76	0.88	0.81	0.86	1.11	0.95	1.10	1.07	0.86
ZrO_2......	0.00	N.p.	0.00	0.00	0.00	0.01	N.p.	0.00	0.00	0.00
CO_2......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
P_2O_5......	1.23	0.76	0.82	0.79	0.52	1.18	1.50	0.96	0.58	0.14
Cl........	0.21	0.16	0.10	0.24	0.17	0.07	0.08	0.26	0.11	0.10
F........	0.10	0.02	0.04	0.16	0.07	0.06	0.17	0.11	0.03	0.04
S........	0.01	0.02	0.23	0.05	0.04	0.09	0.01	0.05	0.03	0.06
Cr_2O_3.....	0.00	N.p.	0.00	0.00	0.00	N.p.	N.p.	0.00	0.00	0.00
MnO.....	0.51	0.30	0.41	1.49	0.96	0.18	0.41	0.64	0.71	0.65
BaO......	0.17	0.25	0.11	0.16	0.10	0.13	0.21	0.16	0.13	0.03
SrO......	0.19	0.29	0.21	0.21	0.17	0.24	0.13	0.16	0.03	0.03
	100.40	100.01	99.64	100.19	100.57	99.53	100.46	100.33	99.98	99.81

Norms of the Lavas Analyzed

	1	2	3	4	5	6	7	8	9	10
Q........	.....	.....	.....	.....	.....	.....	.....	.....	7.9	2.2
Or.......	38.9	39.5	28.4	36.1	28.4	26.1	28.4	14.5	16.1	3.3
Ab.......	18.3	7.9	11.0	8.9	3.7	5.8	.....	.....	19.9	25.7
An.......	13.3	14.2	20.3	13.3	18.9	20.3	17.5	15.3	28.9	38.1
Ne.......	9.7	10.8	8.5	12.5	13.9	7.4	11.9	14.8	.....	.....
Lc.......	.....	.....	.....	.....	.....	.....	3.5	13.1	.....	.....
Hl.......	0.4	.....	.....	0.4	0.2	.....	.....	0.5	0.1	0.1
Di.......	7.1	14.1	16.6	11.1	20.8	23.1	21.3	27.9	4.6	6.9
Hy.......	.....	.....	.....	.....	.....	.....	.....	.....	16.4	17.1
Ol........	1.1	2.5	2.9	5.8	4.2	3.7	4.3	2.6	.....	.....
Mt.......	6.3	5.8	6.7	6.7	6.5	7.7	6.0	6.7	2.3	4.2
Il........	1.4	1.5	1.7	1.5	1.7	2.1	1.8	2.1	2.1	1.7
Pr	.....	.....	0.4	.....	.....	.....	.....	.....	.....	.....
Ap.......	2.7	2.0	2.0	2.0	1.3	2.7	3.7	2.4	1.3	0.3

1. Vicoite, borolanose-monzonose, 'II. 5(6). 2. 3. Gillinan, near Masin. E. W. Morley.
2. Leucite tephrite, borolanose, II. '6. 2. '3. Near Ragou. E. W. Morley.
3. Vicoite, —shoshonose, II. 5(6). '3. 3. Near Ragou. E. W. Morley.
4. Orthoclase-bearing leucite tephrite, borolanose, II. '6. 2. 3. Gillinan. Near Masin. E. W. Morley.
5. Biotite vicoite, borolanose—, II. '6. (2)3. 3. Near Ragou. E. W. Morley.
6. Leucitophyre, kentallenose, 'III, 5. '3. 3. Gillinan, near Masin. E. W. Morley.
7. Leucite tephrite, ourose, (II) III. 6. '3. '3. Near Ragou. E. W. Morley.
8. Vicoite, cascadose, 'III. 7. 2'. 3. Near Ragou. E. W. Morley.
9. Glassy shoshonite, shoshonose, II. (4) 5. 3 (4). 3'. Bromo Crater. E. W. Morley.
10. Basalt, hessose, II. 5. 4. '5. Goentoer lava. E. W. Morley.

The rock whose analysis is No. 1 is a light-gray, aphanitic variety from Kali Gillinan near Masin, which contains rather numerous large phenocrysts of leucite, ranging in size from a diameter of 10 mm. to microscopic dimensions. In thin section they exhibit characteristic polysynthetic twinning, and the index of refraction has been determined by Dr. F. E. Wright to be 1.507 for sodium light. Their chemical composition is shown by the following analysis by Morley:

SiO_2	54.97
Al_2O_3	22.21
K_2O	19.98
Na_2O	0.81
Fe_2O_3	0.61
MgO	0.26
CaO	0.49
H_2O-	0.08
H_2O+	0.56
	99.97

The groundmass is minophyric and dopatic with abundant small phenocrysts of leucite, augite, and some minute feldspars. In thin section it is seen to consist of small phenocrysts of euhedral leucite, zonal augite, and numerous zonal crystals of calcic andesine or labradorite in a holocrystalline groundmass composed of leucite, prismoids of greenish augite, anhedrons of magnetite, with prismoid plagioclase and anhedral orthoclase, some of which form narrow shells around the plagioclase, as in some shoshonites. The calculated norm shows 38.9 orthoclase, 18.3 albite, and 9.7 nephelite, whereas the mode, or actual mineral composition of the rock, shows that no nephelite crystallized from the magma, but considerable albite, which appears in the lime-soda feldspar. Readjusted on this basis the rock might contain about 1.1 orthoclase, 36.2 albite, 29.7 leucite, and no nephelite. Owing to the smallness of the crystals in the groundmass an actual measurement of the mode of the rock cannot be made without great difficulty. The rock may be called a vicoite, which is equivalent to a leucite shoshonite.

The rock of analysis No. 2 is medium gray, very similar to that of No. 1, and occurs on Kali Sekatak near Ragou. The phenocrysts of leucite range in size from 10 mm. downward and in places are

partly separated from the matrix by small spaces or cracks, which indicate that the magma was so stiff just before it solidified that it pulled apart through stretching. In thin section there are small phenocrysts of leucite, augite, magnetite, and reddish-brown biotite, which has an outer zone with weaker absorption than the central part, and in some instances has a margin filled with inclusions. The groundmass consists of leucite, slender prisms of lime-soda feldspar, minute prisms and anhedrons of augite, and magnetite. The chemical analysis and norm show that the rock is a little more femic than the variety first described, No. 1, and that it contains slightly less soda and normative albite. In place of 39.5 per cent of normative orthoclase and 10.8 of normative nephelite, there has crystallized abundant leucite and no nephelite. The rock is leucite tephrite.

The rock of analysis No. 3 is gray, dense, vitreous to subvitreous, and aphanitic, and is from Kali Sekatak. It is minophysic and dopatic, with abundant small phenocrysts of augite. In thin section the groundmass is seen to be holocrystalline and to consist of lime-soda feldspar surrounded by alkalic feldspar, besides anhedral crystals of alkalic feldspar and some leucite, with minute crystals of augite and magnetite. The chemical analysis and norm show this to be a still more femic variety with less alkalies. No nephelite or olivine is recognizable in the rock, and none was observed in Nos. 1 and 2. The rock may be classed as a vicoite, or an orthoclase-bearing leucite tephrite.

The rock of analysis No. 4 is light gray, and aphanitic, from Kali Gillinan. It is dopatic, with small phenocrysts of augite, but no megascopic crystals of leucite or feldspar. In thin section it is seen to contain numerous small phenocrysts of augite, leucite, and very small magnetites, in a holocrystalline matrix composed of prismoid lime-soda feldspar, anhedral orthoclase, leucite, and augite. The chemical analysis and norm are much like those of No. 2, which, however, is characterized by large phenocrysts of leucite. The rock is a variety of leucite tephrite with orthoclase, related to vicoite.

The rock of analysis No. 5 is medium gray, aphanitic, and very porous, from Kali Sekatak, and has some large phenocrysts of

biotite, ranging downward to microscopic crystals, also phenocrysts of augite, but none of leucite or feldspar. In thin section there are abundant small phenocrysts of zonal pleochroic augite, considerable brown mica, zonal lime-soda feldspar, and magnetite, with relatively large crystals of colorless apatite, and a few anhedral, brownish-green hornblendes. There is some ill-defined colorless mineral which may be in part orthoclase, in part leucite. No olivine is to be seen. The chemical composition is very similar to that of No. 3. The norm shows it to be slightly more femic, with more normative nephelite and olivine, and the same amount of normative orthoclase, but the crystallization of abundant biotite accounts for the non-appearance of olivine, and the small amount of leucite without nephelite in the mode. The rock might be classed as a variety of biotite vicoite.

The rock of analysis No. 6 is dark gray and dense, from Kali Gillinan. It is minophyric, sempatic, with comparatively few large phenocrysts of leucite, and abundant small phenocrysts of augite and leucite. In thin section there are abundant leucites, as phenocrysts, as clusters of crystals, and as microscopic crystals in the groundmass. Some clusters of leucites surround augite, others inclose plagioclase, augite, and magnetite. The phenocrysts of augite have pronounced zonal structure; there is a small amount of euhedral olivine. Small crystals of magnetite in some instances have very irregular outlines owing to pockets of groundmass and partly inclosed minute crystals of augite and plagioclase; the outline of the magnetite being rounded in places, as is the case with quartzes having similar partial inclusions. The rounded forms are clearly forms of growth and not of solution, as sometimes suggested. The holocrystalline groundmass contains considerable zonal calcic plagioclase, besides minute crystals of the other mineral constituents of the rock. The chemical analysis and norm show that this variety is more femic than the preceding ones, and that it is richer in normative anorthite. Normative orthoclase and nephelite are represented by modal leucite and by albite in the lime-soda feldspar. Olivine is modal as well as normative. The rock may be called a leucitophyre or leucite basanite.

The rock of analysis No. 7 is gray, dense, and aphanitic with numerous pores, and is found in Kali Sekatak. It has abundant

small phenocrysts of augite, which in thin section are seen to be zonal. The groundmass consists of abundant small leucites with an interstitial matrix composed of augite, magnetite, and minute prismoids of plagioclase. The chemical analysis and norm are very similar to those of No. 5, but the mode differs in having much leucite and no biotite. The rock is a leucite tephrite.

The rock of analysis No. 8 is gray, dense, aphanitic, and non-porphyritic, from Kali Sekatak. In thin section it is seen to be holocrystalline, and to consist of prisms of augite with some magnetite, and many leucites with anhedral orthoclase and anhedral alkalic plagioclase, or lime-soda feldspar surrounded by orthoclase. From the chemical analysis and norm it is seen to be the most femic variety from this region that has been analyzed. There are 13 per cent of normative leucite, and nearly 15 of normative nephelite which does not appear as modal nephelite, but must be represented by albite molecules, and by a greater amount of leucite than appears in the norm. The rock may be considered a variety of non-porphyritic vicoite.

While no crystals of nephelite have been recognized in any of the thin sections of these rocks, some of the specimens collected have numerous cavities with small white hexagonal crystals with basal planes, which appear to be altered nephelite. In other specimens there are cavities containing brilliant square prismatic crystals terminated by pyramidal planes over the edges of the prism, which have the index of refraction and habit of stilbite.

In a region where there are such highly potassic lavas as those of Mt. Mouriah it is to be expected that the lavas of more recent date should contain notable amounts of potash. Through the kindness of Dr. Verbeek a study was made of the thin sections of rocks collected by him and deposited in the Bureau of Mines, in Batavia, in order to learn whether orthoclase-bearing varieties of the andesitic lavas could be found. The collection contains few holocrystalline rocks which show orthoclase borders around prismoids of plagioclase, which might be called shoshonites or trachyandesites. In most cases studied the rocks have a glassy matrix which might contain whatever orthoclase molecules were present in excess of those entering plagioclase crystals. However, the strongly porphyritic glassy lava which occurs in ejected blocks

at the cinder cone of the Bromo volcano in the old Tengger crater, in Eastern Java, has been analyzed chemically with the result shown in analysis No. 9, and proves to be a glassy variety of shoshonite, which shows no orthoclase, or other potassic mineral, in thin section. The dull glassy matrix contains abundant large phenocrysts of calcic plagioclase, having an index of refraction, β, which is 1.560, corresponding to labradorite, $Ab_1An_{1.2}$, and much fewer of brown vitreous augite. In thin section the groundmass is seen to consist of brown glass full of prismoid plagioclase, equant anhedral augite, and magnetite, with phenocrysts of labradorite and a few of augite, olivine, and magnetite.

The recent basaltic lava of Goentoer volcano has been analyzed also, and found to be hessose, with low potash, analysis No. 10. The lava is dark gray, aphanitic, and porous; is minophysic with few large phenocrysts of glassy feldspar with $\beta = 1.575$, which are anorthite, Ab_1An_{10}, and many small ones of less calcic feldspar and glassy yellow olivine. The groundmass contains a small amount of globulitic glass base, between abundant microlites of labradorite and fewer of augite, olivine, and magnetite.

The Pic de Maros is a mountain of igneous rocks covered with vegetation, which forms the southwestern extremity of a short ridge, situated between Maros and Tjamba, north of Makassar, in Celebes. Its rocks are exposed in place in a few localities, but may be seen in great variety in bowlders in the stream Gentungen, in the vicinity of Beleangin, and in loose material in drainage channels at the north base of the mountain. From the last two localities numerous specimens were collected by P. and F. Sarasin and afterward were described by C. Schmidt. In a hurried visit made by one of the authors of this paper some additional observations were made of rocks in place along the road on the west and south flank of the mountain, and some other varieties of rock were collected from the stream Gentungen.

About 5 miles up the road from the rest house, Patinoean, toward Tjamba there are large rounded exposures of massive shonkinite, which is exposed again a mile farther on the same road, and at other places. The rocks are dark colored, medium grained, and are almost perfectly fresh on the rough weathered surface. The

freshness of these rocks along the roadside where not covered by soil and vegetation is extremely interesting and was unexpected, since the rocks are intrusive bodies which have been uncovered by gradual erosion, and are not recent lava flows. They consist of abundant crystals of black mica, the largest 4 mm. in diameter, with euhedral prisms of augite, the largest being 6 mm. long, besides nearly equal amounts of glassy feldspar, some of which is prismoid, while others are anhedral. In thin sections these rocks are seen to consist of nearly equal amounts of mafic minerals and feldspar, which are augite, much brown biotite, considerable magnetite and apatite; the feldspar is almost wholly orthoclase in prismoid sections, with very little lime-soda feldspar. One section shows a little interstitial quartz.

Similar varieties of shonkinite occur as bowlders in the stream Gentungen. One variety at this locality is very similar in general appearance to those just described, but is richer in mafic minerals. It is medium grained, in thin section it might be called coarse grained, and consists of much augite and brown biotite, which crystallized almost synchronously and inclose much colorless apatite, and also magnetite. There is also a very small amount of greenish hornblende which has crystallized around augite. The subordinate felsic components of the rock are chiefly orthoclase, or microperthite, which is slightly cloudy, besides some very transparent calcic plagioclase, and a small amount of interstitial isotropic mineral which is probably sodalite. The chemical composition of this variety of shonkinite is shown by analysis No. 16, and its place in the Quantitative System of Classification is found to be in division III. 6. 3. 2, ottajanose, more exactly its symbol is III. 6. (2) 3. 2. The norm contains over 10 per cent of lenads and 12 per cent of olivine which do not appear in the mode, owing to the large amount of biotite which crystallized from the magma. This variety of shonkinite has been called marosite.

Still another variety of shonkinite found in bowlders in Gentungen is characterized by large poikilitic micas, 20–30 mm. in diameter, which lie in all possible positions in the rock. This variety grades into one in which the micas are not poikilitic, but yield brilliant cleavage plates 10–15 mm. in diameter. In thin

section these two varieties of shonkinite show much mica and augite, with considerable apatite and magnetite. The inclusions in the poikilitic mica are augite and plagioclase. There are large poikilitic crystals of orthoclase, and many small crystals of all the constituent minerals of the rock. The chemical composition of this variety is shown in analysis No. 15, which is not very different from No. 16. Owing to somewhat more calcic feldspar in the norm, which also appears in the mode, the rock belongs in kentallenose, III. 5. 3. 3; more exactly it is III. 5 (6). 3 (4). 3, so that it may be called a biotite kentallenite rather than biotite shonkinite.

Another rock in the Gentungen bears a striking resemblance to the pseudoleucite shonkinite, or fergusite, from Montana, described by Pirsson.[1] It has a dark gray, very fine-grained matrix, with abundant equant, whitish pseudoleucites, irregularly scattered and in clusters, the individual spots being about 3 mm. in diameter; a few, 6 mm. There are also some small poikilitic plates of

TABLE II

CHEMICAL ANALYSES OF ROCKS FROM CELEBES, BORNEO, AND SUMATRA

	11	12	13	14	15	16	17	18	19	20
SiO_2	58.79	58.61	56.31	46.08	45.26	43.98	46.04	46.05	61.91	53.75
Al_2O_3	19.55	21.62	21.69	20.40	15.70	12.28	12.40	14.88	16.26	17.06
Fe_2O_3	1.82	1.16	1.20	2.12	2.44	3.49	3.54	4.22	2.45	4.18
FeO	1.43	0.79	0.97	3.27	6.16	7.70	5.58	5.78	3.96	5.50
MgO	0.74	0.16	0.54	6.30	8.28	8.00	12.60	5.98	1.81	4.07
CaO	2.37	1.71	1.88	8.48	11.95	11.19	8.38	13.47	4.35	7.72
Na_2O	4.21	6.60	5.56	2.07	1.73	1.33	1.62	1.41	4.40	3.33
K_2O	8.69	6.82	9.17	6.72	3.42	5.06	4.87	2.56	3.04	1.37
H_2O+	1.05	1.42	1.13	1.70	1.12	1.61	3.55	3.01	0.18	0.50
H_2O-	0.06	0.19	0.00	0.06	0.29	0.12	......	0.52	0.10	0.39
TiO_2	0.54	0.17	0.41	1.39	1.66	2.24	2.20	0.93	0.79	0.88
ZrO_2	0.00	0.01	0.00	0.00	0.01	0.00	......	0.00	0.00	0.00
CO_2	......	......	......	......	......	......	......	......	......	......
P_2O_5	0.11	0.04	0.13	1.19	0.90	1.81	......	0.59	0.40	0.25
Cl	0.12	0.07	0.28	0.10	0.25	0.12	......	0.09	0.13	0.11
F	0.03	0.01	0.03	0.09	0.08	0.15	......	0.03	0.04	0.06
S	0.02	Tr.	0.17	0.06	0.05	0.10	......	0.04	0.05	0.06
Cr_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	......	0.00	0.00	0.00
MnO	0.40	0.40	0.16	0.19	0.34	0.51	Tr.	0.21	0.20	0.50
BaO	0.08	0.01	0.05	0.11	0.10	0.16	......	0.06	0.02	0.02
SrO	0.12	0.02	0.04	0.07	0.06	0.12	......	0.07	0.06	0.12
	100.13	99.81	99.72	100.40	99.80	99.97	100.78	99.90	100.15	99.87

[1] L. V. Pirsson, *U.S. Geol. Survey, Bull. 237*, 1905, p. 74.

NORMS OF THE ROCKS ANALYZED

	11	12	13	14	15	16	17	18	19	20
Q	......	......	......	......	......	......	......	......	13.3	6.8
Or	51.7	40.0	54.5	26.1	20.0	24.5	25.0	15.6	17.8	8.3
Ab	25.7	35.1	14.7	......	3.1	......	......	9.4	36.2	27.3
An	8.6	8.3	8.1	26.7	26.4	12.8	12.2	26.4	16.4	28.1
Ne	5.4	11.1	16.5	9.4	4.8	5.9	7.4	1.4	......	......
Lc	......	......	......	10.5	......	4.4	3.1	......	......	......
Hl	......	......	0.5	......	0.5	......	......	......	0.2	0.1
C	......	0.4	......	......	......	......	......	......	......	......
Di	1.8	......	0.5	6.6	22.0	24.7	23.0	29.5	2.1	7.0
Hy	......	......	......	......	......	......	......	......	7.7	12.9
Ol	1.5	1.0	0.9	10.5	12.5	11.9	17.3	4.9	......	......
Mt	2.6	1.9	1.9	3.0	3.5	5.1	5.1	6.0	3.7	6.0
Hm	......	......	......	......	......	......	......	......	......	......
Il	1.1	0.3	0.8	2.7	3.2	4.3	4.3	1.8	1.5	1.7
Fl	......	......	......	......	......	0.3	......	......	......	......
Ap	0.3	......	0.3	2.7	2.0	4.4	......	1.3	1.0	0.7

11. Trachyte, pulaskose, I'. 5. '2. '3. Gentungen, Pic de Maros. E. W. Morley.
12. Sodalite trachyte, laurvikose-pulaskose, I. 5 (6). (1) 2. 3 (4). Road at S. W. base of Pic de Maros. E. W. Morley.
13. Nephelite syenite, beemerose-procenose, I. '6. (1) 2. 3. Gentungen, Pic de Maros. E. W. Morley.
14. Fergusite, — II. 6. 3. 2'. Gentungen, Pic de Maros. E. W. Morley.
15. Biotite kentallenite, ourose-kentallenose, III. 5 (6), 3 (4). '3. Gentungen, Pic de Maros. E. W. Morley.
16. Marosite, kajanose-ottajanose, III. 6. (2) 3. 2. Gentungen, Pic de Maros. E. W. Morley.
17. Mica-leucite basalt, kajanose, III. 6. 2 (3). 2'. Oeloe Kajan, East Borneo. Pisani and Brouwer.
18. Absarokite, kentallenose—, III. 5.(3) 4. 3. Road at S.W. base of Pic de Maros. E. W. Morley
19. Andesitic pitchstone, dacose, 'II. 4'. 2.' '4. Simaboer, Mesapi, Sumatra. E. W. Morley.
20. Andesite, andose, II. '5. 3'. 4. Rau Rau, Mesapi, Sumatra. E. W. Morley.

brownish-black mica. In thin section the whitish spots are seen to be microscrystalline aggregations of anhedral alkalic feldspar, apparently orthoclase, and anhedral nephelite. The dark-colored matrix resolves itself into a complex of prismoid and anhedral lime-soda feldspar, augite, somewhat poikilitic biotite, magnetite, and olivine. In places around the areas of pseudoleucite there are clusters of minute anhedrons, having the refractive index of pyroxene, which border small crystals of plagioclase or partly replace them. The chemical composition of this rock is given by analysis No. 14, which belongs in II. 6. 3. 2, and is more calcic, so far as normative feldspars are concerned, than fergusose, II. 6. 1. 2. The rock is an equivalent of nephelite monzonite, but has the habit of fergusite.

Besides the shonkinitic rocks in this region there are various syenitic rocks grading into nephelite syenites and their aphanitic

phases, syenite porphyry, bostonite, and trachyte, and also phonolite, which is said to form the summit of the Pic de Maros. There are varieties intermediate between shonkinite and syenite with subordinate amounts of mafic minerals. A nephelite syenite from the Gentungen is light gray and medium grained, with tabular crystals of orthoclase and quite subordinate amounts of mafic minerals. In thin section the feldspar crystals are seen to have a diverse arrangement, and form the bulk of the rock, through which are scattered stout hexagonal prisms of nephelite about the same size as the crystals of aegirite augite, besides smaller amounts of biotite and brown hornblende, also paramorphs of hornblende and mica, and small crystals of sphene. The chemical composition of this rock is given in analysis No. 13, which is in procenose, its symbol being I. ′6. (1) 2. 3.

There are porphyritic trachytes with tabular phenocrysts of glassy orthoclase, some of which are 40 mm. long and 5 mm. thick. A variety with smaller phenocrysts of orthoclase, 15 mm. long, has a bluish-gray aphanitic groundmass and small equant phenocrysts of mafic minerals. In thin section the groundmass is seen to consist of prismoids and anhedrons of orthoclase, with small amounts of sodic plagioclase, nephelite, and interstitial sodalite. The mafic minerals are greenish-brown hornblende having very irregular outline, in part poikilitic with orthoclase feldspar, also small anhedrons of green augite, and magnetite. Its chemical composition is shown by analysis No. 11, pulaskose I′. 5. ′2. ′3. Part of the normative anorthite enters the mafic minerals, and part must be involved in the alkalic feldspar, which must be sodic orthoclase, for no plagioclase feldspar is recognizable in thin section.

On the road from Patinoean to Tjamba, about 7 miles from Patinoean, there is an exposure of altered tuff containing blocks of massive, light-gray, minutely crystalline rock, with few small phenocrysts of glassy tabular feldspar. Under a lens it is seen to consist of subparallel tabular feldspar with abundant reddish spots. In thin section the rock is seen to be holocrystalline, with trachytoid fabric, composed of anhedral crystals of orthoclase, yielding prismoid sections, some of which show Carlsbad twinning.

Scattered through the whole are anhedral, interstitial crystals of isotropic mineral, probably sodalite. These are small amounts of pale-green augite, brown biotite, and magnetite. The rock is sodalite trachyte, or sodalite bostonite, approaching phonolite in composition. Its chemical composition is shown in analysis No. 12 and corresponds to a variety of pulaskose, I. 5 (6). (1) 2. 3 (4). The norm contains 11 per cent of nephelite and 8 of anorthite, but no lime-soda feldspar is recognizable in thin section. Other varieties of aphanitic, more or less porphyritic, trachytes occur on the north slope of the mountain east of the stream Gentungen, some of which contain small amounts of sodalite; others carry considerable biotite.

At the west base of the Pic de Maros there is a sheet of surface lava which is exposed at the Falls of Maros, or Bantinoeran, and also along the road farther south, about 3 miles east of Patinoean, where it is columnar, and is overlaid by limestone. The rock is coarsely porphyritic with abundant phenocrysts of black euhedral augite, the largest 7 mm. in diameter, and less numerous dark-brown glassy olivines, in a dark-gray aphanitic groundmass speckled with small white spots. In thin section the augite phenocrysts are brownish green, slightly pleochroic, and zonal, the central part being lighter colored than the margin. Olivine is abundant and there is much lime-soda feldspar in small phenocrysts, short prismoid and tabular; besides some prismoid orthoclase and zones of orthoclase surrounding plagioclase. There is a fine-grained matrix of the same kinds of minerals with magnetite and zeolitized feldspathoid mineral which may have been analcite, nephelite, or leucite. The rock is a variety of orthoclase basalt, or absarokite, whose chemical composition is shown by analysis No. 18, III. 5. (3) 4.3, a somewhat more calcic rock than kentallenose, which is III. 5. 3. 3.

A comparison of the analyses of rocks from Mt. Mouriah and the Pic de Maros shows that the leucitic rocks of the one and the shonkinitic rocks of the other locality are chemically similar. They are low in silica, high in potash, and relatively high in alumina and calcium oxide. This shows itself mineralogically in the prominence of leucite in the lavas of Mt. Mouriah, and of orthoclase and

biotite in the phanerocrystalline rocks of the Pic de Maros, while augite is a prominent constituent in both series. The striking contrast between the two groups of rocks is the crystallization of leucite in the lavas, and the absence of nephelite, without any considerable amount of orthoclase, which when present is a microscopic constituent of the groundmass, also the absence of biotite in most phases of the leucitic lavas, although in some varieties biotite and orthoclase have been crystallized at the expense of leucite. While in the intrusive rocks of the Pic de Maros there is no leucite, but considerable nephelite in some instances, abundant orthoclase and biotite, and an absence of noticeable amounts of lime-soda feldspar; in some rocks it is probably present molecularly in considerable amounts. These mineralogical contrasts must be due to differences in chemical equilibrium within chemically similar magmas, resulting from physical differences attending the crystallization of lavas in one case and of intruded magmas in the other. Such contrasts have been pointed out before, but never with so good an illustration.

A pseudoleucite kentallenite, or fergusite, occurs with the shonkinitic rocks in Celebes, the former leucites having been replaced by orthoclase and nephelite. Leucitic lavas occur in the neighborhood of the Pic de Maros, and in numerous other localities in southwestern Celebes,[1] and a mica-leucite basalt with very similar chemical composition to the highly mafic shonkinite, marosite, occurs in East-Central Borneo on the Oeloe Kajan.[2] Strongly potassic magmas yielding leucitic lavas, and biotite-orthoclase phanerites, with more or less nephelite, occur widely scattered from Eastern Java, through Southwestern Celebes, and have been found in East-Central Borneo, so that it is probable that other rocks of this kind will be found in the eastern part of Southern Borneo. The extent of the region in which these leucitic rocks are found, nearly 1,000 miles in length, is much greater than that of Central Italy, which is at present the best-known region of leucitic lavas.

[1] H. Bücking, *Sammlungen des geol. Reichs-Museum Leiden* (Leyden, 1902), pt. 7. 45, and 1904, pt. 8.

F. Rinne, *Zeitschr. d.d. geol. Gesellsch.*, LII (1900), 1.

[2] H. A. Brouwer, *Versl. Kon. Akad. Wetensch. Amsterdam*, 1909.

In addition to the rocks just described from Java and Celebes there are two from Sumatra that have been analyzed in order to learn whether earlier analyses of rocks from the same localities which showed relatively high alkalies were correct. One is a grayish-black pitchstone with many minute phenocrysts that occurs where the road crosses a stream in the village of Semaboer, on the south slope of Merapi volcano, in Central Sumatra. In thin section it is seen to consist of brown globulitic glass base crowded with microlites of prismoid feldspar, pyroxene, and magnetite, with scattered phenocrysts of calcic plagioclase and brown pyroxene. The chemical analysis No. 19 and the norm show that it is dacose, with normal composition for a dacitic andesite-pitchstone without visible modal quartz crystals.

The second rock from this region is dark greenish gray and aphanitic, with minute phenocrysts of feldspar and mafic minerals. It occurs in a small stream near the village of Rau Rau, at the east base of Merapi volcano. In thin section it is seen to be almost holocrystalline, with possibly a little pale-brown glass base between prismoids of plagioclase and smaller prismoids and anhedrons of pyroxene, with magnetite. There are abundant small phenocrysts of calcic plagioclase, fewer larger ones of pale augite, and numerous small olivines. The chemical analysis No. 20 and the norm show the rock is an andose with normal amounts of alkalies. It may be called an olivine-bearing pyroxene andesite.